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LIMING SOILS

An Aid to Better Farming

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Contents

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LIMING SOILS

An Aid to Better Farming

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The use of lime on acid soils is a major step toward better farming.

Lime corrects soil acidity, supplies calcium, improves the availability of some other plant nutrients, and increases the efficiency of fertilizers and manures. It promotes desirable biological activity and improves the structure of certain acid soils.

Liming facilitates the production of green manures and cover crops. Proper liming combined with other desirable soil-management practices usually brings increased yields of better crops.

Records show that liming was practiced in some countries before the Christian era. In colonial times a few farmers limed their soil. During the 19th century the practice became extensive in a few localities, but, except in Pennsylvania, never became general or permanent. At that time farmers had scant knowledge of the need for liming. Moreover, liming materials were often costly and scarce.

Current liming practices are based on well-established facts gleaned from years of research by the United States Department of Agriculture and the State experiment stations. Through the activities of the Federal and State extension services, and through farm conservation practices, farmers have learned more about the value of liming.

Lime use in 1929 totaled barely 4 million tons. The figure doubled by 1939, and doubled again by 1942. The total use in 1947 was 30 million tons but has since declined. Consumption in 1955 was 20.3 million tons.

WHERE LIME IS NEEDED

Most soils east of the "lime line" shown in figure 1 and in some coastal areas of Oregon, Washington, and California need to be limed. In these humid regions, rainfall tends to leach away the lime reserves. In low-rainfall regions, there is little need for liming because the lime reserves have not been leached away or removed by crops to any great extent.

Not all soils of the humid regions need lime. Those that do need it differ greatly in the amounts

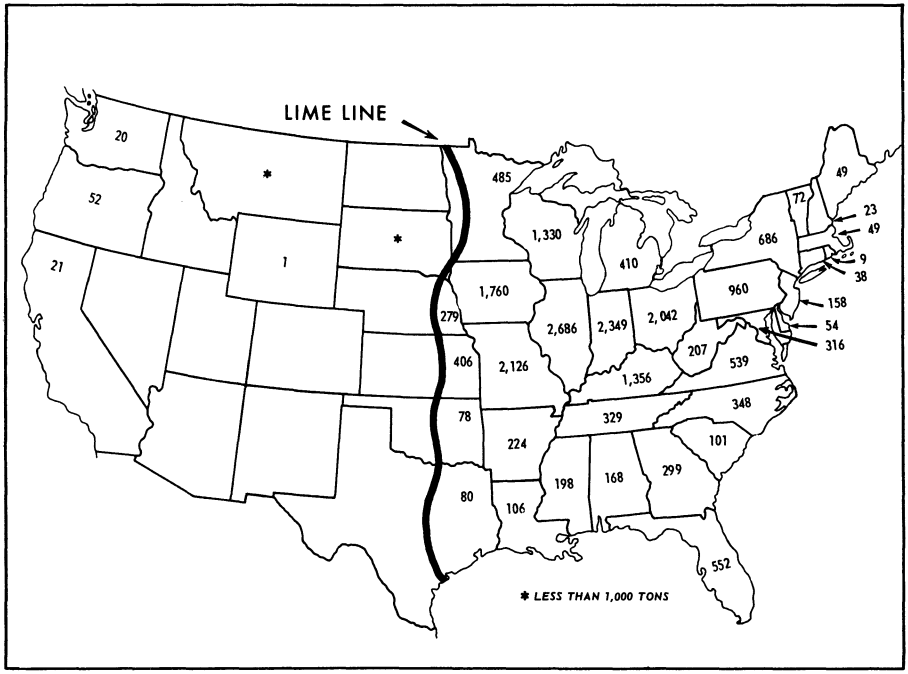

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Figure 1.—Consumption, in 1955, of liming materials, expressed as limestone equivalent, in thousands of tons of limestone. Based on data supplied by the National Agricultural Limestone Institute and the National Lime Association. The "lime line" roughly divides the lime-requiring regions from those where liming is not generally needed.

required. The normal older soils are acid, even though they developed from limy materials. Whether the younger are acid depends largely on local conditions. Some of the nonacid soils are found on rather steep slopes of limestone or other limy materials where erosion removes the acid surface soil nearly as fast as it is formed. Soils on some level land, such as the Black Belt of Alabama and Mississippi, are calcareous. Some bottom lands are very acid; many are not.

Detailed knowledge of local conditions is the only safe guide to liming practices. Farmers in doubt about the lime needs of their fields should consult their county agricultural agent or other local authority. A reason for doubt might be, for example, poor growth or failure of clover crops. Unless it is definitely known that soils are well supplied with lime, tests should be made.

Soil type may at times serve as a rough guide to the need for liming or the amount of lime to apply. Previous liming and cropping history of a soil, however, may upset any conclusions based solely on soil type.

LIMING MATERIALS

Chemically, "lime" means calcium oxide (CaO), more commonly called burnt lime, or quicklime. In agriculture it means any calcium-bearing material capable of correcting soil acidity, such as ground limestone, quicklime, hydrated lime, chalk, marl, blast-

furnace slag, oystershells, sugarmill and papermill waste lime. "Liming" means the application of any liming material to the soil for crop-production purposes.

Gypsum, or land plaster as it is often called, is an excellent source of calcium and sulfur for plants and may have a favorable effect on soil structure. Gypsum does not correct soil acidity. It is, therefore, not a liming material. Gypsum is often used as a conditioner for excessively alkaline soils.

Ground limestone

Ground limestone is the leading material for liming soils. It made up more than 90 percent of all liming materials used in the United States in 1955. Limestone may consist mainly of calcium carbonate ($CaCO_3$), or it may contain both calcium carbonate and magnesium carbonate ($MgCO_3$). Both substances correct soil acidity. Various impurities are also usually present. These have little effect on soil acidity.

Limestone that contains about as much magnesium carbonate as calcium carbonate is called dolomite. Limestone containing lesser proportions of magnesium carbonate is called dolomitic, or magnesian, limestone.

Limestones vary in their texture and hardness. After proper grinding, most of them are suitable for applying to the soil unless they contain so many impurities that unduly large quantities must be applied to obtain the desired liming action.

Limestone deposits are widely distributed in the United States. More than 1,100 quarries produce agricultural limestone. Nearly 85 percent of the farms in the Northeastern States are within 40 miles of an operating limestone source. Sources are not so convenient in all areas where the soils need liming, but in most localities limestone can be obtained without excessive transportation costs.

Limestone is prepared for agricultural use by a relatively simple process. The massive stone is blasted down from the rock face in open-pit or underground quarries. The broken rock is crushed in a primary crusher and then ground. From the grinder it passes over screens that allow only the smaller particles to pass through. The larger pieces are returned to the mill for further grinding until the particle size is reduced sufficiently to meet specifications.

Quicklime and hydrated lime

Quicklime is produced by heating limestone, or some other form of calcium carbonate, to a high temperature. This process drives off the carbon dioxide. The finished product consists mostly of calcium oxide if a high-calcium limestone is used. Some quicklimes, however, contain a considerable amount of magnesium oxide (MgO). When exposed to the air, quicklime absorbs moisture and carbon dioxide to become a mixture of hydrated lime and calcium carbonate. This is called air-slaked lime.

Hydrated, or slaked, lime is formed by adding a little water to quicklime. These liming materials are usually fine powders, but they may contain a few soft lumps.

Air slaking—the absorption of carbon dioxide and moisture by quicklime and of carbon dioxide by hydrated lime—does not reduce the value of these materials for liming. Larger quantities of the slaked products, however, are required to supply a given weight of active lime because of the added weight of the absorbed water or carbon dioxide.

Marl and chalk

Marl is a granular or loosely consolidated, often impure, calcium

carbonate. It is derived from shells of marine animals or formed by precipitation of calcium carbonate from the water of small lakes or ponds. The term is also applied to almost any earthy material that is high in lime, such as some of the calcareous clays. Marl is sometimes nearly pure calcium carbonate, but frequently it has a large content of clay, silt, or organic matter. Since marl is often dug in a wet condition, spreading on the land is difficult unless it is first allowed to dry. Marl is not as widely distributed as limestone and deposits are usually much less extensive.

Digging marl is a simple procedure. Marl often occurs under a slight layer of soil, which is removed by a bulldozer or by other means. The surface of the bed may then be broken up with a disk harrow or plow, and the marl piled for draining and drying or loaded directly into spreader trucks by means of a dragline or other equipment. Disking or plowing the surface layer aids in more rapid drying. Usually, no grinding or crushing is necessary.

Chalk is a soft calcium carbonate rock suitable for liming. It is widely used in England; however, deposits in the United States are restricted to a few localities. Chalk must be ground before being used, but it breaks down easily.

Slags

Blast-furnace slag, a byproduct of the iron industry, is used as a liming material in some areas near where blast furnaces operate. It differs radically from most other liming materials in that its calcium and magnesium contents are present as silicates and not as carbonates or oxides as in limestone or quicklime. Blast-furnace slag compares favorably with many limestones, however, in its calcium carbonate equivalent. It is considered by some persons to be as effective for liming as limestone of the same particle size.

Blast-furnace slag is produced for liming use in two forms—(1) an air-cooled type that must be ground before use, and (2) a water-quenched, or granulated, type. The latter form is generally considered to act more rapidly in the soil than the air-cooled form. Like dolomitic limestone, blast-furnace slag contains magnesium that becomes available to plants.

Basic slag, also a byproduct of the iron and steel industries, is used mainly for its plant-nutrient phosphorus, but it also has value as a liming material.

Calcium silicate slag, a byproduct in the manufacture of phosphorus, has recently come into use as a liming material. This product contains very little magnesium and is also low in phosphorus. It is produced in granulated form, and its action on the soil is similar to that of blast-furnace slag.

Shells and other liming materials

Oystershells and other sea shells are composed mostly of calcium carbonate. When properly ground, such materials are effective liming agents.

Some industrial plants are sources of waste or byproduct limes. These byproducts are often mixtures of hydrated lime, calcium carbonate, and water, together with impurities resulting from the industrial process in which they have been used. Refuse limes from papermills, tanneries, water-softening plants, sugar mills, and acetylene generators, as well as flue dust from cement kilns, are examples. Some are, at times, available in a dry condition. The impurities are usually not harmful, but it is best to consult the county agricultural agent or other adviser before using byproduct and waste limes.

MERITS OF DIFFERENT FORMS OF LIME

All liming materials that have been discussed correct soil acidity and supply calcium for plant nutrition. Any choice among the different materials should be based, therefore, on such factors as cost, the rate at which they correct soil acidity, and their content of plant nutrients other than calcium.

Cost is usually the most important of these factors. Liming materials are nearly always low-priced at the pit, quarry, plant, or other primary source of supply. Frequently a locally produced material far undersells any competing product that must be shipped in. Nevertheless, a choice of materials is sometimes possible, and a farmer should be acquainted with the various factors to be considered.

High-calcium limestone

High-calcium limestone is the standard for comparison. This material corrects soil acidity and supplies nutrient calcium quickly or slowly, according to the fineness of grind and certain other factors.

Dolomitic limestone

Dolomitic, or magnesian, limestone is usually somewhat slower in action than high-calcium limestone of equal fineness. This is not an important factor if the liming is done well ahead of planting. The dolomitic stone supplies magnesium, an important advantage in sections where the soil tends to be low in magnesium. Even in areas where the soil is not deficient in magnesium, it may be well to use the dolomitic stone if little or no extra cost is involved. Magnesium may, of course, be applied in other forms, such as magnesium sulfate or magnesium-bearing potash salts.

Quicklime and hydrated lime

The price of quicklime and hydrated lime includes the cost of processing. These materials, therefore, are always more costly than the limestone from which they were made. In the few areas where all liming materials must be shipped in from distant points, it may cost less to lime with quicklime or hydrated lime than with limestone. Since about 1,000 pounds of quicklime, or 1,200 to 1,400 of hydrated lime, is equivalent to a ton of limestone, the cost of shipping the required amounts of these products is much less than the cost of shipping limestone, provided freight rates are the same for the three products. This factor may outweigh the higher production costs of quicklime and hydrated lime.

Quicklime and hydrated lime are very active chemically, unpleasant to handle, and difficult to store. Foliage may be damaged through contact with quicklime if application is made after the plants come up. Such application, however, is not a common practice. A temporarily over-limed condition of the soil is more likely to occur with these materials than with limestone or slag.

In spite of these drawbacks, it may be advantageous to use quicklime or hydrated lime when a rapid decrease in soil acidity is desired, as in producing truck crops that have a high lime requirement or where a lime-requiring crop follows potatoes. Quicklime and hydrated lime made from dolomitic limestone are good sources of magnesium for crops.

Marl

Marl, except for soft lumps, is usually finely divided and probably reacts slightly more rapidly in the soil than a harder limestone of the same particle size. Aside from this somewhat doubtful advantage, marl is about the equivalent of high-calcium limestone of comparable fine-

ness and analysis. Unlike dolomitic limestone, marl does not supply magnesium, since it is usually very low in this element. It is frequently a low-analysis liming material because of contamination with mineral or organic materials or both, and because it is usually dug in a wet condition. These factors increase the cost of transporting and spreading marl and limit its use to areas near the point where it is dug. For farmers who have the time to dig marl nearby, it is a satisfactory and inexpensive liming material.

HOW TO EVALUATE LIMING MATERIALS

A liming material is judged mainly by two things: (1) Its total capacity to correct soil acidity, and (2) the rate at which it makes this correction. The total capacity to correct soil acidity, or the neutralizing value, is measured by the calcium carbonate equivalent of the material or by its calcium oxide equivalent. The latter is often called the lime oxide equivalent or simply the lime equivalent. The size of the particles of the liming material is usually taken as the best guide to the rate at which soil acidity is corrected by the material. The smaller the particles are, the faster the rate of neutralization. In figure 2, the 3–4 mesh particles are considered too large. The 4–6 mesh particles are acceptable in some States. More commonly, however, the largest acceptable sizes are those in the 8–10 or 10–12 mesh sizes. The 20–24, through 28, and through 60 mesh sizes occur in most agricultural limestones. The agricultural limestone shown contains all sizes of particles 8–10 mesh to the finest dust.

STATE REGULATIONS

Most States where the soil is limed have laws regulating the sale of liming materials. The laws differ in detail, but they have many features in common. Usually a guarantee of chemical analysis and of sieve analysis must be printed on the label of each bag of packaged material or on a document accompanying each bulk shipment. The exact form of guarantee depends on the State law.

Farmers requiring detailed information on the lime law of their State should write the State official or department administering that law. A list of these officials or departments is given on page 29. There are no Federal laws specifically regulating the sale of liming materials. All communications relating to such matters should be addressed to the proper State official.

AGRICULTURAL CONSERVATION PROGRAM SPECIFICATIONS

In the various States where liming materials are distributed under the Agricultural Conservation Program, specifications have been set up that must be met if full credit is to be allowed under the program. Limestone that meets specifications is known as standard ground lime-

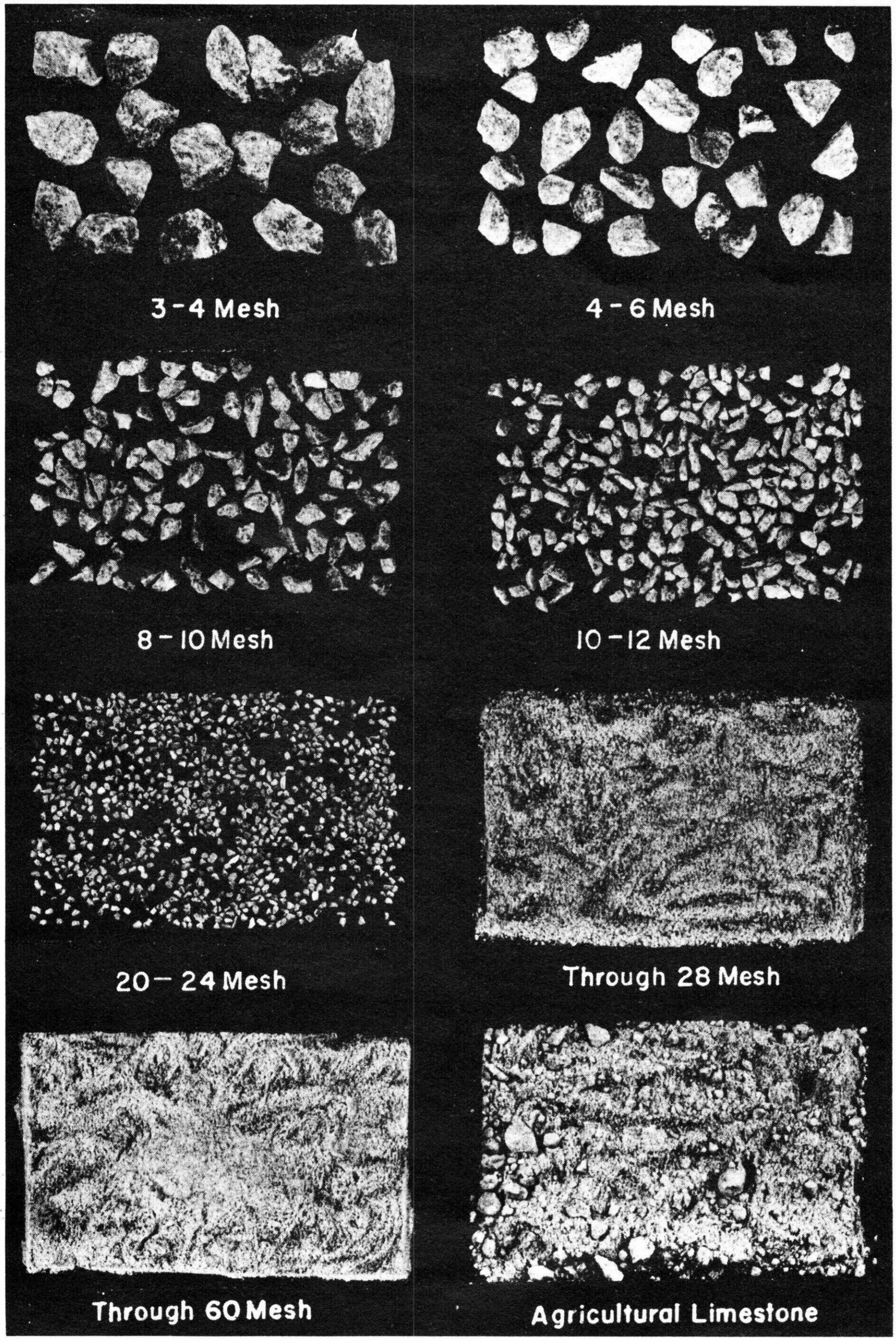

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Figure 2.—Particles of limestone shown actual size.

stone. These specifications, developed in cooperation with State agronomists and other agricultural experts, exist in 38 States. They are adjusted at intervals as conditions warrant.

In addition to these requirements for standard ground limestone, specifications exist in 13 States for other liming materials. The specifications for these materials vary with the State. The varying requirements for liming materials reflect the differing soil and other conditions in the States. A farmer requiring detailed information on the specifications for his State should consult his county or State Agricultural Stabilization and Conservation Committee (addresses on p. 30) or his county agricultural agent.

SOIL NEEDS FOR LIME

The terms "sour" and "sweet" have long been used to indicate relative degrees of soil acidity. These terms, however, are indefinite; they fail to indicate satisfactorily the degree of acidity. Today it is customary to refer to soils formerly termed "sour" as acid, and to the "sweet" soils as neutral or alkaline. The term "soil reaction" now includes the whole range of acidity and alkalinity. The intensities of acidity or alkalinity (reaction) are indicated in a definite, accurate manner by the simple numbers of the pH scale (fig. 3).

A neutral soil has a pH of 7, but soils having pH values between 6.6 and 7.4 are usually considered neutral for practical purposes. As the soil becomes increasingly alkaline, the pH increases upward from 7; as it becomes more acid the pH decreases downward from 7. Farmers should learn the significance of pH and form the habit of describing soil acidity or alkalinity accurately by means of these numbers.

A soil of about pH 6, or higher, is usually assumed to have an adequate supply of available calcium. Broadly speaking, increasing pH means increasing calcium supply. There are a few exceptions. One example is the presence of other bases, such as sodium, that may produce high pH values even when calcium is deficient. Such exceptions are rare in the humid regions. In the following discussion it will be assumed that low pH is associated with low calcium supply, and high pH is associated with high calcium supply. Superphosphate or other fertilizer materials containing calcium may supply that element even in soils of low pH.

Testing soil for pH

Testing soil to determine its pH is a fairly simple process. Rough tests are sometimes made by adding various indicator dyes to a solution made by extracting the soil with a little water. Or, the indicator dyes may be placed directly on the soil under specified conditions. These dyes change color at different pH values. By trying different indicator dyes or by using a mixture of indicator dyes, a fairly accurate pH value can be obtained.

Various portable soil-testing kits are commercially available and are easily used by following the instructions furnished with each kit. Such kits are sufficiently accurate for many purposes. They are widely used by soil technologists, farmers, landscape gardeners, and others.

When highly accurate pH measurements are required, they should

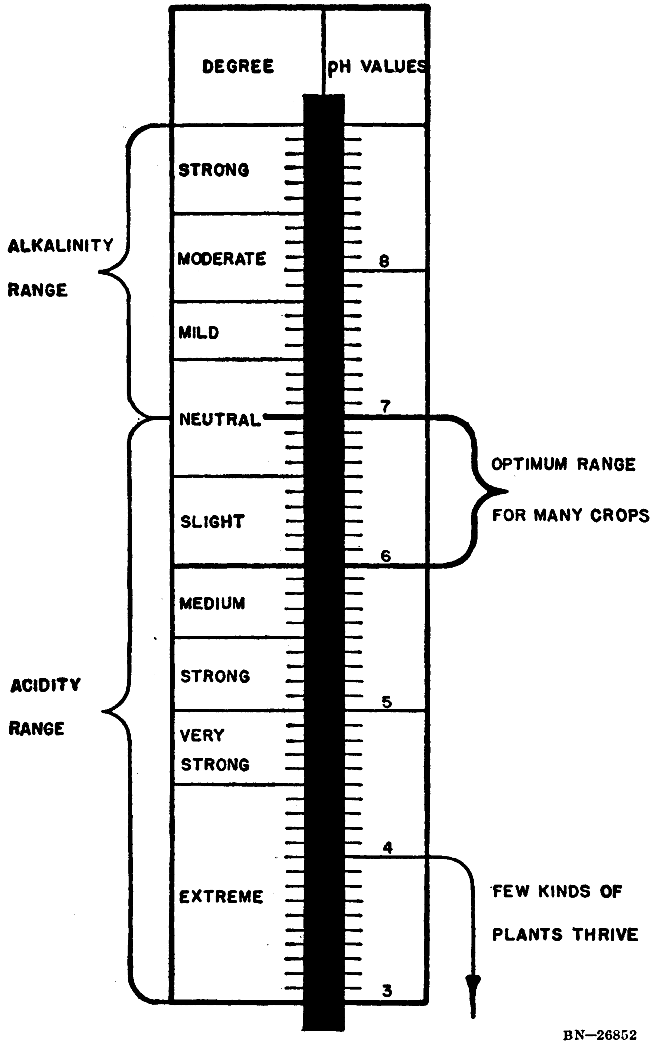

Figure 3.—The pH scale.

be made in laboratories by trained workers using electric pH meters especially adapted for soil work. Tests with these meters can be made very rapidly. State or commercial laboratories generally use such equipment.

Amounts to use

The amount of lime required depends on the kind of liming material used, the particular crop and rotation system involved, the type of soil, and on other factors.

Table 1 shows application rates recommended for various soil regions and textural classes of soils. These are general recommendations and are not intended to replace detailed information that frequently can be obtained from county agents or other local advisers.

In using the table add together the amounts of lime required to

change the pH of the soil from its initial value all the way to the pH desired. For example, if the initial pH is 4.5, the soil is a sandy loam located within the temperate region, and a final pH of 6.5 is desired, add together 0.8 and 1.3. This gives 2.1 tons—the amount of limestone required to change the pH from 4.5 to 6.5. Do not expect the same amount of lime to change a soil from pH 5.5 to 6.5 as will change the pH of that soil from pH 3.5 to 4.5 or from 4.5 to 5.5. For most soils, more lime is required for a unit change in pH as the soil becomes less acid.

Most State agricultural experiment stations provide a soil-testing service. These agencies will usually make pH tests and any other tests needed to estimate the lime requirement of the soil. The results of such tests, considered in conjunction with the nature of the soil and its previous history, provide the basis for lime recommendations. Sampling of the soil for such tests should be done in accordance with instructions furnished by these agencies.

TABLE 1.—*Approximate amounts of finely ground limestone needed to raise the pH of a 7-inch layer of soil as indicated* [1]

Soil regions and textural classes	Limestone requirement per acre [2] to increase—		
	From pH 3.5 to pH 4.5	From pH 4.5 to pH 5.5	From pH 5.5 to pH 6.5
Soils of warm-temperate and tropical regions:	*Tons*	*Tons*	*Tons*
Sand and loamy sand	0. 3	0. 3	0. 4
Sandy loam		. 5	. 7
Loam		. 8	1. 0
Silt loam		1. 2	1. 4
Clay loam		1. 5	2. 0
Muck	2. 5	3. 3	3. 8
Soils of cool-temperate and temperate regions:			
Sand and loamy sand	. 4	. 5	. 6
Sandy loam		. 8	1. 3
Loam		1. 2	1. 7
Silt loam		1. 5	2. 0
Clay loam		1. 9	2. 3
Muck	2. 9	3. 8	4. 3

[1] From Soil Survey Manual.

[2] For quicklime use slightly more than ½ the amounts indicated; for hydrated lime, about ¾. The suggestions for mineral soils are for those of average organic matter content. If such soils are low in organic matter, reduce the recommended amounts by about 25 percent; if unusually high in organic matter, increase by about 25 percent, or even more. The suggestions for muck soils are for those essentially free of sand and clay. For those containing much sand or clay the amounts should be reduced to values midway between those given for muck and the corresponding textural class of mineral soil. For example, the lime required to raise the pH of a muck soil high in sand, and occurring in the cool-temperate or temperate regions, from 4.5 to 5.5 would be 2.2 tons per acre, or midway between the value for muck (3.8) and that for sand and loamy sand (0.5).

CROP NEEDS FOR LIME

Crops differ as to the range of soil pH at which they grow and produce best. They also differ in the amount of calcium required for their nutrition.

Suitable pH ranges for various crops and ornamental plants are shown in figure 4. These ranges indicate the pH values at which a particular crop grows best in most areas under most conditions, and do not imply that a crop will not grow outside the indicated range. Corn, for example, is highly tolerant of a wide range of soil pH. However, soil not more than slightly acid (pH of about 6.5) is usually desirable for best corn production when clovers and other legume plants are grown in the rotation. On the other hand, a distinct degree of soil acidity is necessary for growing certain acid-loving plants such as blueberries, cranberries, and azaleas. Potatoes grow well over a wide range of pH, but they are likely to become scabby as the soil acidity is reduced from strong to medium.

Plants of high calcium content require a soil of good lime status more than those containing less calcium. But the relationship between the calcium content of a plant and the soil pH at which it grows well is not a close one. Alfalfa and most of the clovers absorb relatively large quantities of calcium and grow well in soils that are nearly neutral, or slightly alkaline. Crimson clover, however, readily obtains calcium from soils that are more acid in reaction and less well supplied with lime. Cereals, as a rule, contain relatively little calcium and grow well in soils of moderate calcium content if the supplies of other nutrients are adequate. Plants seem to differ in their ability to obtain needed calcium at various pH levels.

Best liming practices are determined mainly by the crops included in the rotation system. Certain crops, for example alfalfa, thrive only at relatively high soil pH. In grassland farming where many different forages are involved, liming practices will vary, but a liming program to fit the crop needs is essential to success.

APPLYING LIME

When to apply lime

Most forms of lime may be applied at any time of the year. No one season is best; the important thing is to get the needed lime on the land. In the Northern States it is a common practice to spread lime during the winter when the ground is frozen hard enough to support spreader equipment.

Limestone, marl, and slag may be spread whenever the ground is firm and crops do not interfere. It is often advisable to add these forms of lime several months in advance of a growing season to allow adequate time for their reaction with the soil. Very acid soils should be limed 6 months before seeding legumes, then limed again just before seeding if the acidity was not adequately corrected.

Hydrated lime and quicklime react quickly. For certain vegetable crops, these liming materials are often added at a low rate near the time of planting or transplanting. The legume or legume-grass part of a rotation is the crop most likely to benefit from added lime. Therefore, a good place to apply lime in a rotation is during tillage preceding the legume or legume-grass crop.

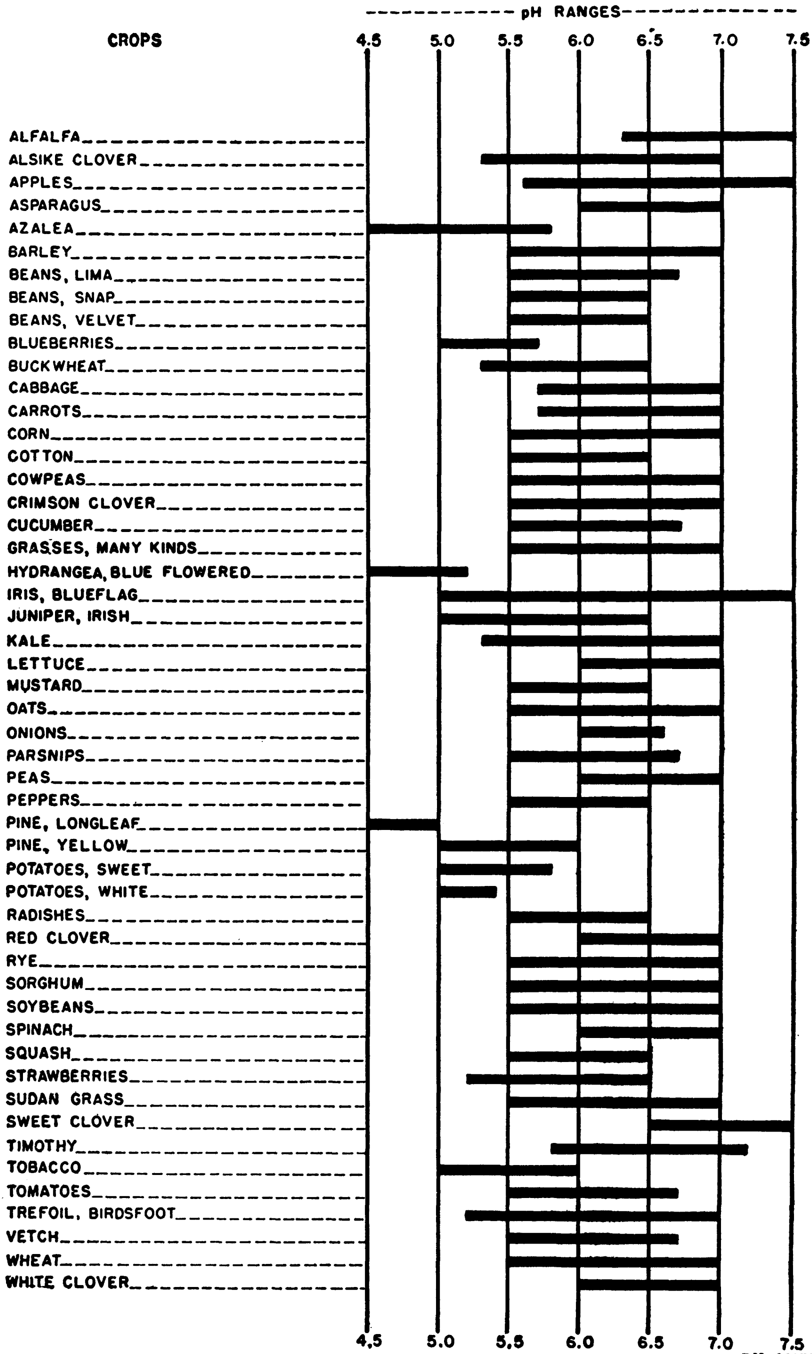

Figure 4.—Suitable pH ranges for various crops and ornamental plants.

Frequency of application

Soil should be limed whenever the pH falls below the optimum range for the crop being grown. How often this will occur depends on several factors. The best guide, however, is a periodic testing of the soil pH at different depths within the root zone. Inspections at intervals not greater than 2 years are advisable.

The type of liming material is an important factor in determining the frequency of application.

Ground limestone that contains particles varying from about 10-mesh size downward tends to have an immediate liming effect through the action of the smaller particles, and a slower effect from the larger particles. The result is a liming action that may extend over several years before the limestone is all consumed, or before the soil pH falls to an undesirably low level.

Hydrated lime and quicklime are usually composed almost entirely of very fine particles that react quickly in the soil. It is generally advisable to lime more often and at lighter rates if these materials are used.

The application rates of limestone and slag may be higher than those of the more reactive materials and the applications may be less frequent. Heavy applications should be used with caution in regions where there is danger of overliming. In the Corn Belt, however, large quantities of lime are frequently added to make it effective over a period of years. Under other circumstances, as in potato fields, it may be desirable to lime only to the extent necessary for growing hay crops in the rotation.

Sometimes lime is applied once in a rotation of 4 to 6 years. In farming that is essentially of the grassland type, applications at intervals of 8 to 10 years are common.

Using more lime than the soil needs may be wasteful, or may cause yield reductions. Drastic increases in soil pH from excessive limestone applications may on certain soils be accompanied by a marked reduction in the availability of such nutrient elements as boron, manganese, copper, and zinc. This is especially probable where the supply of these elements in the soil is low. On some soils, excess lime seems to interfere with the absorption of phosphorus or potassium, or both. Broadly speaking, the relatively infertile soils—especially those that are sandy and low in organic matter—are more susceptible to overliming injury than the more fertile ones.

Large applications of quicklime or hydrated lime may cause a temporarily high soil pH that may be detrimental to growing crops. When using these active limes, it is especially desirable to guard against overliming. This is more important if the lime is to be applied after or near planting time. Dolomitic limestone and slag are generally less liable to produce overliming than high-calcium limestone.

Methods of applying

Most lime used on United States farms is applied directly from the trucks that deliver it to the farm (fig. 5). This method of spreading relieves the farmer of the chore of handling the material, and may often be done more cheaply than by using farm labor. However, a farmer may do a more even job of spreading, and he may be able to utilize farm labor at slack times. He can also spread the lime at the best time. Dealers are not always able to deliver and spread lime just when the farmer wants it. When a truck spreader is used, the farmer should be sure that the driver thoroughly covers all the land, especially the corners of a field.

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Figure 5.—A lime-spreading truck.

Modern lime-spreading trucks are usually hopper shaped and have an endless, or screw-type, conveyor located in the bottom. This conveyor continuously moves the material back to the spreading mechanism mounted on the rear of the truck. Two types of spreading mechanisms are the fan, or spinner, type (fig. 6) and the transverse-conveyor type.

The conveyor in the hopper of the spinner type delivers the limestone onto a rapidly rotating horizontal circular "fan," or spreading disk. Radiating vanes attached to the disk throw the material out. Usually two such disks are used. This type is simple and inexpensive, and can remain in place while the truck is moving over highways. One disadvantage of the spinner type is that it tends to throw larger particles in a wide arc and to drop smaller particles near the center of the swath. This trouble can be partly corrected by lapping enough to get fine particles on all the soil. Spinner-type spreaders are sometimes equipped with a special hood that reduces dusting and appears to give more uniform spreading.

The transverse type (fig. 7) consists of two conveyors, each of which accepts the material from the hopper conveyor, takes it to one side, and allows it to fall through holes spaced along the bottom of the conveyor or over a tapered plate. Shields may be added to reduce dusting (fig. 8). Both transverse conveyors and hoods must be dismounted or folded up while the truck is on the highway.

Farmers who do their own spreading use a variety of equipment, including the conventional

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Figure 6.—A spinner-type spreader. (Courtesy of Highway Equipment Co.)

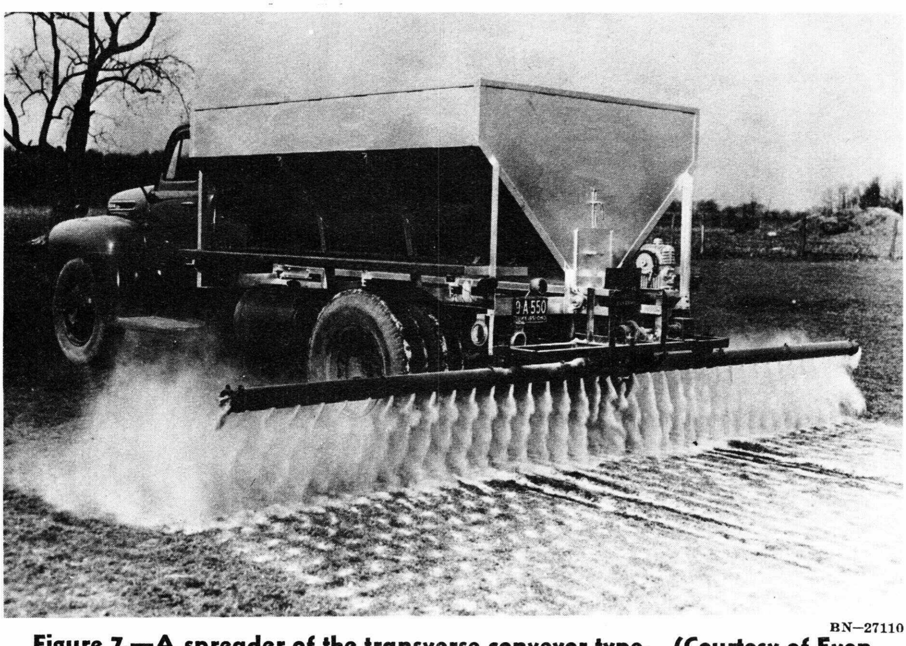

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Figure 7.—A spreader of the transverse conveyor type. (Courtesy of Even Spread Co.)

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Figure 8.—A truck spreader equipped with a hood. (Courtesy of Highway Equipment Co.)

lime broadcaster, which resembles a seeder except that it has a larger box. When using this type, it is convenient, though usually more expensive, to buy the lime in bags for easier handling. Such spreaders are preferred when the soil is too wet to support heavy trucks; when the fields are small, hilly (fig. 9) or of irregular shape; and when crop requirements demand uniform spreading of small amounts of liming material.

Fan-type spreaders designed to be pulled behind a truck or wagon (fig. 10) are also used. The lime is shoveled from the truck into the spreader as it moves over the field. Farmers handy with tools sometimes make their own spreaders (fig. 11).

Spreading limestone with manure

Ground limestone may be placed on top of a load of manure in a manure spreader (fig. 12) so that limestone and manure are spread simultaneously. In windy weather the limestone may be put at the bottom of the load. Up to about 200 pounds of limestone per ton of manure can be used in this manner without causing appreciable losses of nitrogen from the manure. Furthermore, there should be little reduction in the availability of the phosphoric acid in superphosphate added to the manure. Hydrated lime and quicklime are often used in the gutter on fresh manure. They should not be allowed to come in contact with other manure, even if it is only a few hours old, as loss of nitrogen may result.

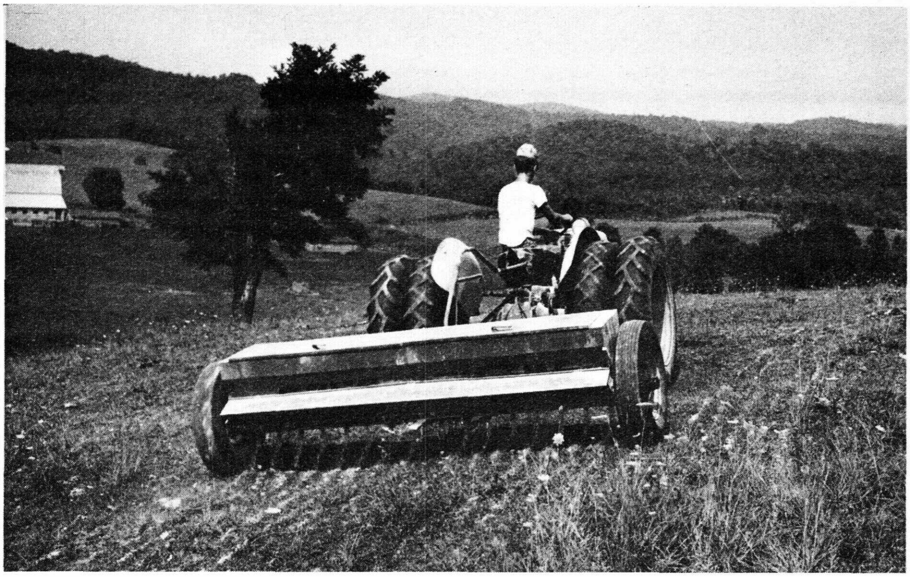

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Figure 9.—A lime spreader drawn by a tractor. (Courtesy of Soil Conservation Service, W. Va.)

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Figure 10.—A lime spreader designed to be towed by a truck. It is the double spinner type.

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Figure 11.—A homemade lime spreader. The spinner is driven by an old car axle.

Treatment of limed land

Lime applied on the surface should be worked into the soil where possible. Lime applied on relatively smooth and bare soil surfaces may be extensively lost by erosion, particularly on sloping land. The best manner of working lime into the soil depends on the cropping system and other factors.

Applying lime on plowed ground before disking and harrowing usually results in adequate mixing of the lime and soil. Deep disking is especially effective. A split application, one-half applied before plowing and one-half after, is desirable on land that is strongly acid. When all the lime is applied on the surface and plowed under, the plowing may bring acid soil to

the surface while placing the lime beyond the roots of many plants especially in the early stages of growth.

Lime applied to pastures in which the soil has a low pH value usually gives marked benefits even though it is not often feasible to work it into the soil. The cover of grass and other plants tends to hold it there against erosion. Many of the pasture plants are able to feed very near the surface and so derive benefits from surface application more quickly than deep-rooted plants do.

Where a pasture is renovated, lime should be applied prior to the disking, since this operation helps to work the lime into the soil. This encourages deeper rooting of the pasture plants, which in turn aids in making them more drought resistant.

COST OF LIMING

The total cost of agricultural limestone to the farmer is composed of three things: (1) The costs of quarrying, grinding, screening and any other processing cost at the plant; (2) the cost of transporting the limestone to the farm; and (3) the cost of spreading it on the land.

The respective Agricultural Stabilization and Conservation Committees have estimated averages or ranges of these costs in 1956 in the States consuming large amounts of agricultural limestone. These costs vary widely from State to State and even within a particular State. This is especially true of the cost

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Figure 12.—Spreading limestone on a load of manure.

Table 2.—*Average costs of standard ground limestone in bulk as variously estimated by State Agricultural Stabilization and Conservation Committees, 1956. States not listed use little or no soil liming material*

State	Estimated average cost per ton			
	At plant	Transportation to farm	Spreading charge	Delivered and spread
Alabama	$1.85	$3.15	$2.00	$7.00
Arkansas	1.25	3.25	.75	5.25
California	8.00	8.00	2.00	18.00
Connecticut	[1] 4.65	3.50	1.40	9.55
Delaware	2.90–3.10	(2)	(2)	5.80–8.00
Florida [3]	2.60	2.00	1.50	6.10
Georgia	2.00	3.00	1.85	6.85
Illinois	1.45	[4] 2.00	----------	3.45
Indiana	1.39	1.39	.53	3.31
Iowa	1.35	1.25	.50	3.10
Kansas	1.50	1.75	.50	3.75
Kentucky	1.50	[5] .08	.50	----------
Louisiana	.85	[6] 1.75	1.21	7.36
Maine	[7] 4.80	[8] 4.24	2.97	12.01
Maryland	2.75	3.00	2.00	7.75
Massachusetts	[9] 5.00	3.20	1.50	9.70
Michigan	2.00	2.65	.75	5.40
Minnesota	1.39	1.52	.81	3.72
Mississippi	.75	5.10	.65	6.50
Missouri	1.60	1.05	.50	3.15
Montana [10]	----------	----------	----------	8.00
Nebraska	1.75	3.25	1.00	5.72
New Hampshire	4.00	4.50	3.00	11.50
New Jersey	3.25–4.75	1.50–2.75	2.00	6.75–9.50
New York	3.70	3.30	1.50	8.50
North Carolina	.95	[11] 1.50	1.00	6.35
Ohio	2.10	1.80	.95	4.85
Oklahoma	1.75	2.00	.75	4.50
Oregon	7.00	4.00	1.00	12.00
Pennsylvania	3.40	2.50	1.25	7.15
Rhode Island	5.75	2.25	1.50	9.50
South Carolina	2.20	3.10	1.50	6.80
Tennessee	1.58	1.84	.60	4.02
Texas	1.00–1.25	(12)	[4] 3.00	4.00–4.25
Vermont	(13)	(14)	1.00	7.80
Virginia	1.35	3.00	1.25	5.60
Washington	6.75	2.58	1.50	10.83
West Virginia	2.00	1.65	1.00	4.65
Wisconsin	1.25	1.84	.60	3.69

[1] $5.90 bagged.
[2] Not separately estimated.
[3] For high-calcium limestone. Corresponding figures for dolomite are $4.40, $2, $1.50, and $7.90.
[4] Transportation to farm plus spreading charge—not separately estimated.
[5] Per mile.
[6] Railhead to farm. Average rail freight, $3.55.
[7] $5.90 bagged.
[8] $4.13 bagged.
[9] $6 bagged.
[10] Much sugar refuse lime is used, obtained free at the plant. Estimated average cost of transportation per ton is $2.50 and of spreading, $0.50.
[11] Railhead to farm. Average rail freight, $2.90.
[12] Rail freight, $2.08 to $2.22.
[13] $5 bagged, not estimated for bulk limestone.
[14] $2.50 bagged, not estimated for bulk limestone.

of transportation to the farm, which is largely dependent on the widely varying distances from plant to farm. The individual farmer may have paid more or less for his limestone than the values indicated in table 2. This depends on local conditions. An Iowa farmer applying 2 tons per acre on 100 acres might have had a bill of approximately $620. A Maine farmer might have paid about $2,400 and a California farmer $3,600 for the same material and service.

Costs of liming with quicklime or hydrated lime will be much higher in most localities. In some areas it may be possible to use marl or by-product liming materials at costs lower than those of standard ground limestone.

ACID-FORMING FERTILIZERS AND LIMING

Certain fertilizers—ammonium sulfate, urea, ammonium nitrate, ammonium phosphates, and ammonia—tend to make the soil more acid. Calcium cyanamide, sodium nitrate, and calcium nitrate, however, tend to make the soil less acid. The superphosphates, the common potash salts, and some of the organic fertilizers, have little or no effect on soil acidity. Mixed fertilizers affect the soil acidity to varying degrees. The extent of this effect depends on their composition, and on whether dolomitic limestone has been included in the mixture to overcome any acid-forming tendency.

The tendency of some fertilizers to make the soil more acid should cause little concern where an adequate liming program is followed. For an extreme example, suppose ammonium sulfate—one of the most highly acid-forming fertilizers—is applied at the very heavy rate of 500 pounds per acre. It would take 550 pounds of limestone to overcome the acid-forming tendency of this application. The acid-forming tendencies of mixed fertilizers are seldom more than a small fraction of that of ammonium sulfate.

A farmer should realize that he pays much more for limestone that has been included in a mixed fertilizer to correct its acid-forming tendency than he would have to pay for a little additional lime applied directly to the soil. If a check is kept on the soil acidity, and lime is applied when it is needed, the effect of any acid-forming fertilizers will be automatically compensated and may be largely ignored. Similarly, the effect of the fertilizers that make the soil less acid can be ignored. Their effect is too slight to have any significant influence on the liming program.

LIME ON LAWNS AND GARDENS

Soil pH in a new lawn should be 6.0 to 6.5 to a depth of 4 to 6 inches. The best material to use is dolomitic limestone, but high-calcium limestone, quicklime, or hydrated lime may be used. The quantities necessary are easily determined from table 1. Since it is convenient to figure rates of application for small areas in terms of pounds per 1,000 square feet, change tons to pounds. An area of 1,000 square feet is roughly 1/40 acre.

Lawn soil prepared in this manner will probably not need more lime for 5 to 10 years. Whenever the pH falls below 5.8, make a surface application of 25 to 50 pounds per 1,000 square feet. If the soil is

properly limed, clovers may be grown with the lawn grasses. This reduces the need for nitrogen fertilizers.

Lime does not take the place of fertilizer and other established practices. Many lawns are overlimed and underfertilized.

Garden soils often receive large amounts of fertilizers containing superphosphate. The calcium content of such materials may supply part of the needed calcium. However, liming may still be required to bring the pH within a range suitable for plant growth and to supply the balance of the calcium. Most common vegetables and flowers grow well at soil pH values ranging from 5.8 to 7.0, but pH 6.5 is a desirable midpoint.

Garden composts may need added lime to hasten decomposition. A suggested rate is 40 pounds of lime per ton of dry organic matter. Do not add lime if the compost is to be used for acid-loving plants.

The proper use of soil testing is the best guide to correct liming practice.

FUNCTIONS OF LIME

Lime has various functions. It may correct soil acidity, supply calcium and magnesium to plants, improve soil structure. Lime may also have an indirect effect on the availability to plants of nutrients and other elements. In addition, lime may affect microbiological activity in the soil.

Correcting soil acidity

Some of the acids of acid soils are soluble; some insoluble; some mineral; and some are organic in nature. The insoluble acids result when hydrogen combines with the surfaces of colloids. (Colloids are fine particles of clay and well decomposed organic matter.) When a liming material is added to an acid soil, the calcium and magnesium in the lime exchange places with the hydrogen on the surfaces of the colloids and in the soluble acid. This action makes the hydrogen non-acid, thus neutralizing the soil.

The degree of this exchange determines the intensity of the acid condition. If the exchange is complete, the soil acidity is completely neutralized and the pH of the soil is 7. Since this complete action is not always desirable, it is better to speak of the "correction of soil acidity" rather than its "neutralization." Correction of acidity means elimination of the acid hydrogen to the degree desired. A degree that corresponds to pH 6.5, for example, is a condition suitable for the growth of many kinds of plants.

Supplying calcium and magnesium

Some plants such as alfalfa, clovers, and certain leafy vegetables require large amounts of calcium. Plants of these types thrive best when the predominant base in the soil is calcium. If other bases such as magnesium, potassium, or sodium are present in the soil in amounts equal to or higher than the calcium, nutritional disturbances occur. Fortunately, our cheapest soil neutralizers—limestone and its derived products—contain calcium as the chief base.

Calcium assists root development, the movement of carbohydrates within the plant, formation of cell walls, seed production, and other processes.

If a plant is low in calcium, its growth may be adversely affected. Animals that eat plants low in calcium may in turn suffer from calcium deficiency.

Bones, teeth, milk, and eggshells normally contain large amounts of calcium. This element is essential to normal growth and body functioning.

A magnesium deficiency often accompanies a calcium deficiency. Magnesium is an essential component of chlorophyll—the green coloring matter of plants. Magnesium promotes the formation of oils and fats; it is abundant in seeds. It also is necessary for animal life.

Plants usually do not require as much magnesium as calcium.

Improving soil structure

Soil productivity depends partly on its texture and structure. Texture is the proportion of sand, silt, clay, and organic matter. Structure is the arrangement of these particles into larger granules and aggregates. Soil structure can often be modified by management practices. In general, the best physical condition exists when the soil is highly aggregated and granulated. Liming an acid soil promotes this condition indirectly because of the increased penetration and permeation of the soil by plant roots.

Effects on nutrients and other elements

Acidity and liming have important effects on the solubility, availability, and sometimes the toxicity, of a number of elements. Many of these elements are essential to plant growth. As acidity increases, the solubility of aluminum, copper, iron, manganese, and zinc also increases. Sometimes toxic concentrations of these elements may occur in highly acid soils. This can be remedied by decreasing the acidity. Aluminum and manganese, especially, have been shown to be toxic in certain very acid soils. Some crops thrive on acid soils, apparently not because of a reduced need for calcium, but of a higher requirement for certain other elements.

General relationships between the degree of acidity and the availability of 11 plant nutrients are indicated in figure 13. Only general trends can be indicated in this manner; individual situations may depart widely from this behavior.

Acidity and liming also indirectly affect the availability of the three principal fertilizer nutrient elements—nitrogen, phosphorus, and potassium.

Generally, an increase in soil acidity adversely affects nitrogen-fixing bacteria associated with the roots of legumes and those living free in the soil. Thus, the availability of nitrogen declines.

At a moderate to strong acidity status, many soils fix fertilizer phosphate by forming highly insoluble compounds of phosphorus with iron and aluminum. When this condition exists, phosphate must be applied more frequently and in larger quantities. Around neutrality, the iron and aluminum are much less soluble, and much of the phosphate is combined with calcium in a more readily available form. In the alkaline range, excess calcium tends to reduce the availability also, because a more insoluble calcium phosphate occurs.

For its potassium supply a plant depends largely on the exchangeable potassium, the more readily decomposable fraction of the mineral reserves, and the potassium contained in fertilizers and manures. Liming and acidity affect the availability of these sources. At lower potassium levels, liming may affect the rate of release from mineral sources either directly by chemical processes or by the increased growth of plants that often results from liming.

If the supply of calcium and magnesium in soil is low and that

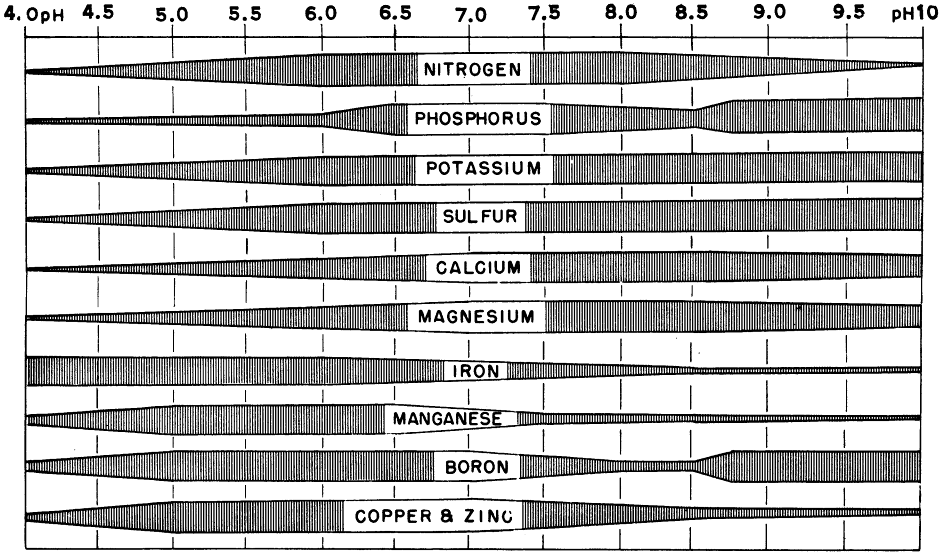

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Figure 13.—Effect of soil pH on the comparative availability of 11 plant nutrients. For each nutrient the width of the band is an index of its relative availability.

of potassium relatively high, potassium-induced calcium and magnesium deficiency may occur, resulting in reduced growth of poor quality. Lime applications usually increase the yield of legumes and other high-calcium plants. Sufficient potash must be supplied to satisfy the requirement of the larger crop.

Despite the number of ways in which the availability of the essential nutrient elements is beneficially or adversely affected by liming, a proper balance can usually be managed. For a large number of crops, on soils well supplied with nutrients, maintenance of the soil pH between 6 and 7 can be expected to provide a satisfactory condition with respect to nutrient availability.

As one result of the possible explosion of numbers of nuclear bombs during war, the surface soil layer in some areas might contain hazardous amounts of radioactive fission products from fallout. One of these fission products is strontium 90, a relatively long-lived isotope (half-life, 28 years) of the element strontium. Strontium is chemically similar to calcium and tends to accumulate in living bones as calcium does. This potential problem is discussed in Farmers' Bulletin No. 2107 (revised November 1965), "Defense Against Radioactive Fallout on the Farm."

The fraction of the soil content of strontium 90 that is absorbed by the first crops following deposition of fallout is reduced by increases in the amount of available calcium in the soil. Therefore, an additional benefit of liming acid soils would be a reduction in the

amount of this hazardous radioactive contaminant in food and feed crops following the explosion of nuclear weapons in a war. Liming of soil for this purpose might be done either before or after the land was contaminated. Lime applications for the various crops, however, should not exceed those recommended in this bulletin.

Effect on soil micro-organisms

Soil contains a variety of micro-organisms, such as bacteria, fungi, and algae. The numbers and kinds of micro-organisms present in soil may vary according to the degree of soil acidity, moisture content, amount and composition of organic matter, and other factors.

Soil micro-organisms are helpful to agriculture because they decompose organic matter and liberate nutrients that can be used by plants. During the process of decomposition, or decay, certain acids are formed. Unless there is sufficient calcium available, these acids tend to raise the soil acidity. This acid condition may reach a point where the activity of soil micro-organisms declines or even ceases. Adding lime to the soil, however, reduces the soil acidity and permits the decomposition to proceed.

One of the more important nutrients that bacteria make available to plants is nitrogen. Most of these nitrogen-fixing bacteria thrive best in soil that is approximately neutral. Adding lime, therefore, creates more favorable conditions for the bacteria, regardless of whether they are native to the soil or added as inoculation cultures.

LOSS OF LIME FROM SOIL

Lime does not remain in the soil indefinitely. It may be lost through removal by plants, leaching by percolation of water, runoff of rain water, and erosion. Different soils and different areas are affected to varying degrees.

Removal by plants

Plants vary widely in their uptake of calcium and magnesium, the two main plant nutrients supplied by lime. For example, dry alfalfa leaves may contain 2 percent of calcium and dry potato tubers only 0.04 percent. Even different parts of the same plant often contain greatly different quantities of these nutrients.

The calcium and magnesium content of the total production from an acre of a given crop may also vary widely (table 3). This variation is influenced by: plant variety, soil type, amount of available calcium and magnesium in the soil, weather, rate of growth, and yield.

Generally, plants containing a higher percentage of calcium are the legumes, such as alfalfa, red clover, sweetclover, cowpeas, lespedeza, and soybeans; the leaves of broadleaved vegetables, such as cabbage and turnips; and other broadleaved crops like tobacco. Small grain crops, such as barley, flax, oats, rye, and wheat, contain little calcium either in the grain or in the straw. Fruits and root vegetables usually contain a low percentage of calcium. In certain crops, such as corn and soybeans, the major portion of the calcium is in the stover and hay. Allowing these residues to remain on or in the soil aids in retaining calcium for use by crops that follow.

Removal by leaching

The quantities of calcium lost in drainage water are extremely variable. Soils that are coarse-textured to a considerable depth permit extensive passage of water through to the lower layers of soil. Conditions within the root zone greatly

TABLE 3.—*Approximate quantities of calcium and magnesium contained in the harvested portions of various crops*

Crop	Yield per acre	Calcium	Magnesium
		Pounds	*Pounds*
Alfalfa	3 tons	100	20
Apples	300 bushels	1	1
Barley, grain	40 bushels	1	2
Barley, straw	1 ton	3	1
Beet roots, red	10 tons	5	3
Bluegrass	2 tons	15	5
Cabbage	10 tons	30	10
Carrots	5 tons	5	2
Clover, red	2 tons	50	15
Clover, sweet	do	40	10
Corn, grain	50 bushels	1	3
Corn, stover	3,000 pounds	10	5
Cotton, lint	500 pounds	1	1
Cotton, seed	1,000 pounds	2	5
Cowpea hay	2 tons	50	15
Flax, grain	15 bushels	2	3
Flax, straw	1 ton	10	3
Lespedeza	2 tons	50	10
Oats, grain	50 bushels	1	2
Oats, straw	2,500 pounds	5	2
Onions	400 bushels	10	5
Potatoes	do	2	7
Rye, grain	20 bushels	1	1
Rye, straw	1 ton	3	1
Soybeans, grain	25 bushels	10	10
Soybeans, hay	2 tons	30	15
Timothy hay	do	10	5
Tobacco	1 ton	50	10
Turnips, leaves	5 tons	60	20
Turnips, roots	10 tons	10	5
Wheat, grain	30 bushels	1	3
Wheat, straw	3,000 pounds	5	2

influence the quantities of calcium removed by water. Some idea of the magnitude of such losses is shown by an experiment in New York where leaching caused an annual loss of 257 pounds of calcium per acre. A Florida experiment showed annual losses of 98 pounds.

When crop growth is dense and rainfall not excessive, percolation past the root zone may be virtually eliminated. Loss of lime can increase if rainfall is excessive. Losses tend to be greater in sandy soils because of their greater porosity. Since some period of contact is necessary to bring the lime into solution, the degree of loss is influenced by the rate at which water moves through the soil. Solid lime particles do not move very far.

The largest part of lime loss occurs in the form of calcium and magnesium bicarbonates in solution after the dissolving of lime particles or replacement of exchangeable calcium and magnesium. This may temporarily enrich the subsoil at the expense of the surface soil. Leaching should be regarded as a total loss only when it extends below the root zone of the crop. The subsoils of some areas contain free lime of natural origin, although the surface soil may be acid. The creation of such an extreme situation by liming practices is unlikely.

Removal by runoff and erosion

Runoff of clear rainwater is not likely to remove much lime. Areas from which such water is removed by surface drainage are usually well protected by vegetation. If it rains soon after lime is applied to a pasture or other sodded area, however, some loss by solution or suspension in the runoff water may occur.

Erosion presents a greater hazard. Lime applied to the soil just before a rain will be almost completely lost if the surface is eroded. The beating action of raindrops may puddle bare soil surfaces so that the infiltration of rain is slowed or even prevented, regardless of lime status. This increases the runoff, and the combined actions of puddling and sheet erosion can seriously deplete the surface soil of its available lime.

If the lime has not been applied just prior to a rain, however, the loss may be no more serious than that of the other essential soil components.

STATE AGENCIES ADMINISTERING LIME LAWS AND REGULATIONS[1]

Alabama	Dept. of Agr. and Indus., 525 Dexter Ave., Montgomery, Ala. 36101
Arizona	State Chem., P.O. Box 1130, Mesa, Ariz. 85202
California	Field Crops and Agr. Chemicals, Dept. of Agr., 1220 N St., Sacramento, Calif. 95814
Colorado	Feed and Fert. Control, Dept. of Agr., 1525 Sherman St., Denver, Colo. 80203
Delaware	State Bd. of Agr., Dover, Del. 19901
Florida	Dept. of Agri., Insp. Div., Nathan Mayo Bldg., Tallahassee, Fla. 32304
Georgia	Commr., Dept. of Agr., Agr. Bldg., 19 Hunter St., SW., Atlanta, Ga. 30303
Idaho	Dept. of Agr., Feed and Fert. Div., State House, Boise, Idaho 83702
Iowa	Dept. of Agr., East 7th & Court Sts., Des Moines, Iowa 50319
Kentucky	Div. of Weights, Dept. of Agr., Frankfort, Ky. 40601
Maine	Div. of Insp., Dept. of Agr., State House, Augusta, Maine 04330
Maryland	State Chem., State Insp. Serv., College Park, Md. 20742
Massachusetts	Regulat. Serv., Agr. Expt. Sta., Amherst, Mass. 01003
Michigan	Dept. of Agr., State Office Bldg., Lansing, Mich. 48913
Minnesota [2]	Div. of Agronomy Services, Dept. of Agr., State Office Bldg., St. Paul, Minn. 55101
Missouri [3]	Dept. of Agr., Jefferson City, Mo. 65102
Montana	Dept. of Agr., 616 Helena Ave., Helena, Mont. 59601
Nevada	Div. of Plant Indus., Dept. of Agr., P.O. Box 1209, 350 Capitol Hill Ave., Reno, Nev. 89502
New Jersey	State Chem., Agr. Expt. Sta., New Brunswick, N.J. 08903
New Mexico	Dept. of Agr., Feed and Fert. Control Office, Box 366, University Park, N. Mex. 88070
New York	Div. of Food Control, Dept. of Agr. and Markets, State Office Bldg., Albany, N.Y. 12225
North Carolina	Dept. of Agr., Raleigh, N.C. 27603
Ohio	Div. of Feeds and Fert., Dept. of Agr., Reynoldsburg, Ohio 43068
Oregon	Dept. of Agr., Salem, Oreg. 97310
Pennsylvania	Bur. of Foods and Chem., Dept. of Agr., P.O. Box 689, Harrisburg, Pa. 17120
Rhode Island	Div. of Markets, Dept. of Agr. and Conserv., Veterans Memorial Bldg., Providence, R.I. 02903
Tennessee	Feeds, Seeds and Fert. Div., Dept. of Agr., State Office Bldg., Box 9039, Nashville, Tenn. 37204

[1] States not listed have no lime law.
[2] The agency has the authority to regulate the sale and distribution of liming materials should the need arise.
[3] The law applies only to limestone selling for $10 a ton or more.

Texas	Dir., Feed and Fert. Control Serv., A & M College, College Station, Tex. 77843
Utah	Dept. of Agr., Salt Lake City, Utah 84114
Vermont	Regulat. Serv., Univ. of Vt., Burlington, Vt. 05401
Virginia	Fert. Lime and Motor Fuel Sec., Div. of Markets, Dept. of Agr., 203 N. Governor St., Richmond, Va. 23219
Washington	Grain and Chem. Div., Dept. of Agr., Box 120, Olympia, Wash. 98501
West Virginia	Dept. of Agr., Capitol Bldg., Charleston, W. Va. 25305
Wisconsin	Chief, General Lab. Div., Dept. of Agr., Feed and Fert. Sec., 4702 University Ave., Madison, Wis. 53705
Wyoming	Commr. of Agr., Dept. of Agr., 308 Capitol Bldg., Cheyenne, Wyo. 82021
Puerto Rico	Commonwealth of Puerto Rico, Dept. of Agr., Santurce, P.R. 00908

STATE AGRICULTURAL STABILIZATION AND CONSERVATION COMMITTEES

Alabama	474 South Court St., Montgomery, Ala. 36104
Alaska	954 Cowles St., Fairbanks, Alaska 99701
Arizona	Fed. Bldg., 230 N. First Ave., Phoenix, Ariz. 85025
Arkansas	New Fed. Office Bldg., 700 W. Capitol Ave., P.O. Box 2781, Little Rock, Ark. 72203
California	2020 Milvia St., Berkeley, Calif. 94704
Colorado	New Custom House, Denver, Colo. 80202
Connecticut	College of Agriculture, Storrs, Conn. 06268
Delaware	Courtney and Academy Sts., Newark, Del. 19711
Florida	412 N.E. 16th St., Gainseville, Fla. 32601
Georgia	Old Post Office Bldg., P.O. Box 1552, Athens, Ga. 30601
Idaho	5903 Franklin Road, P.O. Box 37, Boise, Idaho 83701
Illinois	U.S. Post Office & Courthouse, Springfield, Ill. 62701
Indiana	Park Bldg., 311 W. Washington St., Indianapolis, Ind. 46204
Iowa	Iowa Bldg., 505 Sixth Ave., Des Moines, Iowa 50307
Kansas	Wareham Bldg., 417 Humbolt St., Manhattan, Kans. 66502
Kentucky	1409 Forbes Road, Lexington, Ky. 40505
Louisiana	3737 Government St., Alexandria, La. 71303
Maine	University of Maine, Grove St., Orono, Maine 04473
Maryland	Symons Hall, University of Maryland, P.O. Box 38, College Park, Md. 20740
Massachusetts	6 Main St., Amherst, Mass. 01002
Michigan	1405 S. Harrison Rd., East Lansing, Mich. 48823
Minnesota	Griggs Midway Bldg., 1821 University Ave., St. Paul, Minn. 55104
Mississippi	Milner Bldg., 200 S. Lamar St., P.O. Box 1251, Jackson, Miss. 39205
Missouri	I.O.O.F. Bldg., 10th & Walnut Sts., Columbia, Mo. 65201
Montana	211 N. Grand Ave., P.O. Box 149, Bozeman, Mont. 59715
Nebraska	5801 O St., P.O. Box 793, Lincoln, Nebr. 68501
Nevada	1479 S. Wells Ave., Reno, Nev. 89502
New Hampshire	Fed. Bldg., P.O. Box E, Durham, N.H. 03824
New Jersey	College Farm, New Brunswick, N.J. 08903
New Mexico	Fed. Bldg., 517 Gold Ave., SW., P.O. Box 1706, Albuquerque, N. Mex. 87103
New York	Midtown Plaza Bldg., 700 East Water St., Syracuse, N.Y. 13210
North Carolina	1330 St. Mary's St., Raleigh, N.C. 27605
North Dakota	15 S. 21st St., P.O. Box 2017, Fargo, N. Dak. 58103
Ohio	Old Fed. Bldg., Columbus, Ohio. 43215
Oklahoma	Agr. Center Office Bldg., Stillwater, Okla. 74074
Oregon	Ross Bldg., 209 SW. 5th Ave., Portland, Oreg. 97204
Pennsylvania	2-H Riverside Office Center, 2101 N. Front St., Harrisburg, Pa. 17110
Rhode Island	329A U.S. Post Office, Providence, R.I. 02903
South Carolina	Fed. Office Bldg., 901 Sumter St., P.O. Box 660, Columbia, S.C. 29202
South Dakota	239 Wisconsin St., SW., P.O. Box 843, Huron, S. Dak. 57350
Tennessee	U.S. Courthouse, Nashville, Tenn. 37203
Texas	USDA Bldg., College Station, Tex. 77841
Utah	125 So. State St., Salt Lake City, Utah 84111

Vermont	481 Main St., Burlington, Vt. 05401
Virginia	New Fed. Bldg., 400 N. 8th St., Richmond, Va. 23240
Washington	Bon Marche Bldg., 214 N. Wall St., Spokane, Wash. 99201
West Virginia	209 Prairie Ave., P.O. Box 1049, Morgantown, W. Va. 26504
Wisconsin	4601 Hammersley Rd., P.O. Box 4248, Madison, Wis. 53711
Wyoming	345 E. Second St., P.O. Box 1211, Casper, Wyo. 82602
Caribbean area	1409 Ponce de Leon Ave., Stop 20, Segarra Bldg., P.O. Box 8037, Fernandez Juncos Station, Santurce, P.R. 00910
Hawaii	303 Dillingham Bldg., Honolulu, Hawaii 96813

TERMS USED IN LIMING

Acid-forming fertilizer.—A fertilizer that tends to increase the acidity of the soil (lower the soil pH).

Acid-neutralizing value (A. N. V.).—*See* Calcium carbonate equivalent.

Agricultural liming material.—A material whose calcium and magnesium content is capable of correcting soil acidity.

Agstone.—Agricultural limestone.

Air-slaked lime.—A product composed of varying proportions of the oxide, hydroxide, and carbonate of calcium, or of calcium and magnesium, formed by exposure of quicklime or hydrated lime to the atmosphere.

Base.—(*a*) The metallic element combined in a salt, as sodium in sodium chloride or calcium in calcium sulfate, or (*b*) the alkaline compounds formed by such elements, as calcium hydroxide or oxide, or sodium hydroxide.

Bog lime.—Marl.

Builder's lime.—*See* Calcium oxide.

Burnt lime.—*See* Calcium oxide.

Calcareous.—Consisting of, or containing, calcium carbonate.

Calcite.—The common crystalline form of calcium carbonate.

Calcium.—One of the metallic elements. It never occurs in nature in the free form but only in combination with other elements. It is an essential constituent of teeth, bones, shells, and plants.

Calcium carbonate (carbonate of lime).—Calcium carbonate is a compound consisting of calcium oxide combined with carbon dioxide gas. It occurs in nature as limestone, marble, chalk, marl, mollusk shells, coral, eggshells, and similar substances.

Calcium carbonate equivalent.—The sum of the calcium and magnesium oxide contents of a liming material when both are expressed as their equivalents in calcium carbonate. It is usually expressed as a percentage. For pure limestone the value is 100 percent; for pure dolomite it is 108.6 percent. The calcium carbonate equivalent is also referred to as the neutralizing value, or acid-neutralizing value (A. N. V.).

Calcium hydroxide.—The chemical combination of calcium oxide (quicklime) and water. *See also* Hydrated lime.

Calcium oxide.—The chemical compound composed of calcium and oxygen. It is formed from calcium carbonate (limestone) by heating to drive off the carbon dioxide; also known as quicklime, unslaked lime, burnt lime, lump lime, stone lime, caustic lime, or builder's lime. It does not occur in nature.

Calcium oxide equivalent.—The percentage of calcium oxide in a liming material plus 1.39 times the magnesium oxide percentage. For pure limestone the value is 56.0 percent; for pure dolomite it is 60.8 percent.

Carbonate of lime.—*See* Calcium carbonate.

Caustic lime.—*See* Calcium oxide.

Chalk.—A soft limestone of earthy texture; white, gray, or buff in color; composed chiefly of the shells of Foraminifera.

Dolomite.—Limestone containing magnesium carbonate in an amount equivalent, or nearly so, to the calcium carbonate content of the stone. Limestone containing magnesium carbonate in lesser proportions is properly called magnesian limestone or dolomitic limestone.

Exchangeable base.—A basic element held on the surface of a colloid but capable of being replaced or exchanged by other basic elements or by hydrogen.

Green manure.—Any crop that is plowed under to replenish the organic matter of the soil. Leguminous crops, as clovers and cowpeas, are grown most frequently for this purpose, but nonleguminous plants, such as rye, are sometimes used.

Ground limestone.—A product made by grinding either limestone or dolomitic limestone.

Gypsum.—A hydrated form of calcium sulfate, also known as land plaster. It supplies calcium to the soil, but it does not correct acidity; hence, it is not a liming material.

Humus.—The well-decomposed, more or less stable part of the organic matter of the soil. It is made up of a great variety of organic compounds.

Hydrated lime.—Calcium hydroxide (slaked lime), formed by adding sufficient water to quicklime to combine with the oxides.

Land plaster.—*See* Gypsum.

Lime.—Chemically, calcium oxide. The term is broadly applied in agriculture to any material containing calcium or calcium and magnesium in forms capable of correcting soil acidity.

Lime equivalent.—Same as calcium oxide equivalent.

Lime requirement.—The quantity of lime required to bring an acid soil to neutrality or to some desired degree of acidity or pH. It is usually stated in terms of pounds of calcium carbonate per acre necessary to bring the first 6 inches of soil to the desired pH.

Lump lime.—Quicklime as it comes from the lime kiln. *See* Calcium oxide.

Magnesian limestone.—Limestone containing varying proportions of magnesium carbonate. *See* Dolomite.

Magnesium carbonate.—The compound consisting of magnesium oxide combined with carbon dioxide gas. It occurs in nature as the mineral magnesite, and as a constituent of magnesian limestone and dolomite.

Magnesium oxide.—The chemical compound composed of magnesium and oxygen. It is formed from magnesium carbonate (magnesite) by heating to drive off the carbon dioxide, or, in mixture with calcium oxide, by heating magnesian limestone or dolomite. Also known as magnesia, it occurs in nature as the mineral periclase.

Marble.—A compact, hard, polishable form of limestone.

Marl.—A granular, or loosely consolidated, earthy material composed largely of calcium carbonate as shell fragments (shell marl) or formed by precipitation in ponds. It contains varying amounts of silt and organic matter.

Mechanical analysis.—Indicates the percentages of the particles of a material that fall within predetermined size limits, or between certain mesh sizes. Also referred to as screen analysis, sieve analysis, and particle-size distribution.

Neutralizing value.—*See* Calcium carbonate equivalent; Calcium oxide equivalent.

Organic matter.—Animal or vegetable material of any origin. It includes material in all states of decomposition.

Oxide of lime.—*See* Calcium oxide.

pH.—A measure of the degree of acidity or alkalinity of a soil. Specifically the numbers (1–14) of the pH scale are the logarithms of the reciprocal of the hydrogen ion concentration expressed in gram molecules of hydrogen ion per liter.

Pulverized limestone (fine-ground limestone).—A product made by grinding either limestone or dolomitic limestone finely enough that all the material passes through a 20-mesh sieve and at least 75 percent passes through a 100-mesh sieve.

Quicklime.—*See* Calcium oxide.

Screen analysis.—*See* Mechanical analysis.

Shell marl.—*See* Marl.

Sieve analysis.—*See* Mechanical analysis.

Slag.—A waste material formed when a fluxing material combines with the unwanted constituents of an ore or an impure metal.

Slaked lime.—*See* Hydrated lime.

Soil reaction.—The acidity or alkalinity status of a soil. Soils that are acid are said to have an acid reaction; those that are alkaline are said to have an alkaline reaction.

Standard ground limestone.—Ground limestone that meets the chemical and mechanical analysis requirements for limestone to be distributed under the Agricultural Conservation Program in a particular State.

Total oxides.—A term applied to the simple sum of the percentages of calcium and magnesium oxides in a liming material.

Waste lime.—Waste, or byproduct, lime is any industrial waste or byproduct from such sources as tanneries, sugar mills, and acetylene plants. It contains calcium and magnesium in forms that correct soil acidity when applied to the land.

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